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Verification of the Translation

I, Kazuo Ueda, being conversant in both of the Japanese and the English languages, do hereby verify that the attached is a true English language translation of the specification of Japanese Patent Application No. 2003-069954, filed on March 14, 2003.

Date: November 25, 2005

Signature: Kazuo Ueda

Kazuo Ueda

Patent Application Number 2003-069954 (2003.03.14)

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filed on March 14, 2003)

[Document type] Specification

[Title of the Invention]

Micro power converter with plural outputs

[Claims]

1. A micro power converter with plural outputs comprising:

a semiconductor substrate having semiconductor integrated circuit(s);

a plurality of thin film magnetic induction components each formed on a magnetic insulative substrate;

a magnetically isolating layer that magnetically isolates the thin film magnetic induction components from each other; and

a capacitor(s).

2. The micro power converter with plural outputs according to claim 1, wherein the magnetic insulative substrate is a ferrite substrate.

3. The micro power converter with plural outputs according to claim 1, wherein the thin film magnetic induction components are magnetically isolated with each other by a nonmagnetic material.

4. The micro power converter with plural outputs according to claim 3, wherein the nonmagnetic material is a resin material.

5. The micro power converter with plural outputs according to claim 3, wherein the nonmagnetic material is a ceramic material.

6. The micro power converter with plural outputs according to any one of claims 1 through 5 comprising a pair or pairs of the connection terminals, one terminal of the pair of connection terminals being formed on a first principal surface of the magnetic insulative substrate, the other terminal of the pair of connection terminals being formed on a second principal surface of the magnetic insulative substrate, and the terminals of the pair of terminals being electrically connected through a through hole formed in the magnetic insulative substrate.

7. The micro power converter with plural outputs according to claim 6, wherein some of the connection terminals electrically connect to the semiconductor substrate.

8 The micro power converter with plural outputs according to claim 6 or claim 7, wherein some of the connection terminals electrically connect to the capacitor.

[Detailed Description of the Invention]

[0001]

[Technical field of the invention]

The present invention relates a micro power converter, such as a DC-DC converter, for plural outputs. The micro power converter comprises a semiconductor integrated circuit (hereinafter abbreviated to IC) formed on a semiconductor substrate and passive components including coils, capacitors, and resistors.

[0002]

[Background of the invention]

Electronic information apparatuses, particularly a variety of portable electronic information apparatuses have been remarkably popularized in recent years. Many of the electronic information apparatuses have a battery as a power source and are equipped with a power converter such as DC-DC converter. The power converter generally has a structure of a hybrid type module comprising discrete parts of active components and passive components arranged on a printed circuit board of ceramics or plastics. The active components include switching devices, rectifying devices and controller ICs; the passive components include coils, transformers, capacitors and resistors.

Fig. 16 shows a circuit diagram of a DC-DC converter. Inside of the peripheral dotted line 50 represents a DC-DC converter circuit.

[0003]

The DC-DC converter comprises an input capacitor Ci, an output capacitor Co, a regulator resistor RT, a capacitor CT, an inductor L, and a power supply IC. DC voltage Vi is input; MOSFETs of the power supply IC switch on and off; and specified DC output voltage Vo is output. The inductor L and the output capacitor Co are parts of a filter circuit for output of a DC voltage.

If the DC resistance of the inductor L in the circuit increases, voltage drop in the part increases resulting in decrease of the output voltage, Vo, which means decrease of conversion efficiency of the DC-DC converter. Miniaturization of the portable and other variety of electronic information apparatuses strongly needs miniaturization of a power converter installed in the apparatus. Miniaturization of hybrid type power supply modules has been progressing by means of MCM (multiple-chip module) technique and laminated ceramics parts technique. However, packaging of discrete parts arranged on one substrate restricts reduction of a package area of the power supply module. Magnetic induction components such as inductors and transformers, in particular, which occupy much larger volume than ICs, impose most severe restraint on miniaturization of electronic apparatuses.

[0004]

Miniaturization of the magnetic induction components could be sought along two directions; a direction in which the total size of the

power supply is reduced by planar packaging of chip parts miniaturized to an extreme limit, and another direction in which thin film parts are formed on a silicon substrate. Some examples have been disclosed recently in which thin micro magnetic components, for example coils and transformers, are mounted on a semiconductor substrate applying semiconductor technology, in response to demand for minimizing magnetic induction components. The inventors also devised such a planar type thin film magnetic induction component. (See Patent document 1).

This is a planar magnetic induction component (a thin film inductor) comprising a thin film coil sandwiched by a magnetic thin film and a ferrite substrate formed by a thin film technology on a surface of a semiconductor substrate incorporating semiconductor components such as switching elements and controller circuits. A thin film type magnetic induction component and reduction of packaging area were achieved by this device. Problems, however, remain in that many discrete chip parts still exist and packaging area is large yet.

[0005]

To solve the problems, the inventors further devised a micro power converter that has already been disclosed. (See Patent document 2). A planar magnetic induction component installed in this micro power converter is formed by filling a gap of a spiral-shaped coil conductor with resin containing magnetic fine particles

and sandwiching the coil conductor with ferrite substrates.

The inventors also devised a micro power converter exhibiting high efficiency by combining a power supply IC and an inductor formed with a solenoid-shaped coil. The micro power converter is described in Japanese Patent Application No. 2003-008714.

[0006]

[Patent document 1]

Japanese Unexamined Patent Application Publication No. 2001-196542

[Patent document 2]

Japanese Unexamined Patent Application Publication No. 2002-233140

[0007]

[Problem to be solved by the invention]

The micro power converter proposed by the inventors and described above, though small and thin, has only one magnetic inductor component and one IC, and directs to a single output system with one input and one output. Consequently, a plurality of the micro power converters is required to obtain a plurality of outputs.

Many of portable and other electronic apparatuses that demand a micro power converter need a plurality of outputs, that is, need a plurality of output voltages. Therefore, a plurality of the micro power converters is necessary and the packaging area for the converters is large, resulting in an increased packaging cost.

[0008]

Therefore, an object of the present invention is to solve the above problems and to provide a micro power converter with plural outputs, the converter supplying a plurality of output voltages, being small and thin, occupying small packaging area, and having a plurality of output systems.

[0009]

[Means to solve the problems]

To attain the above object, a micro power converter with plural outputs according to the present invention contains the following features.

A micro power converter with plural outputs of the invention comprises a semiconductor substrate having semiconductor integrated circuit(s), a plurality of thin film magnetic induction components each formed on a magnetic insulative substrate, a magnetically isolating layer that magnetically isolates the thin film magnetic induction components from each other, and a capacitor(s).

The magnetic insulative substrate is advantageously a ferrite substrate.

The thin film magnetic induction components are advantageously magnetically isolated with each other by a nonmagnetic material.

[0010]

The nonmagnetic material is advantageously a resin material.

The nonmagnetic material is advantageously a ceramic material.

A pair (or pairs) of the connection terminals are provided; one terminal of the pair of connection terminals is formed on a first principal surface of the magnetic insulative substrate, the other terminal of the pair of connection terminals is formed on a second principal surface of the magnetic insulative substrate, and the terminals of the pair of terminals are electrically connected through a through hole formed in the magnetic insulative substrate.

Advantageously some of the connection terminals electrically connect to the semiconductor substrate.

Advantageously some of the connection terminals electrically connect to the capacitor.

[0011]

[Aspects of embodiment of the invention]

[Example 1]

Fig. 1 and Fig. 2 show an essential structure of a micro power converter with plural outputs of a first example of embodiment according to the present invention. Fig. 1 is a top plan view of an inductor that is a thin film magnetic induction component. Fig. 2(a) is a cross sectional view along the line X-X of Fig. 1. Fig. 2(b) is a cross sectional view along the line Y-Y of Fig. 1. There are two inductors in this example. These figures contain not only coil patterns of the inductors but also connection terminals 15a and 15b that are packaging terminals of the inductors for electrical connection.

[0012]

In Fig. 1, coil conductors 12a and 13a are formed on the first principal surface of magnetic insulative substrates 11 and coil conductors 12b and 13b are formed on the second principal surface of the substrates. The coil conductors 12b and 13b formed on the second principal surface have a straight linear form in a plan view. The coil conductors 12b and 13b electrically connect to the coil conductors 12a and 13a on the first principal surface through connecting conductors 14 formed in through holes. Each of the coil conductors 12a and 13a on the first principal surface, connecting to an adjacent coil conductor of the coil conductors 12b and 13b on the second principal surface through the connecting conductor 14, is formed slightly oblique with respect to the coil conductors 12b and 13b. (The figure is drawn in exaggeration.) The coil conductor 12a, the coil conductor 12b, and the connecting conductor 14 form a solenoid coil, and the coil conductor 13a, the coil conductor 13b, and the connecting conductor 14 form another solenoid coil.

[0013]

A magnetically isolating layer 17 is formed of a nonmagnetic material between the magnetic insulative substrates 11. The magnetically isolating layer 17 magnetically isolates an inductor 1 that is a thin film magnetic inductive component composed of the magnetic insulative substrate 11, the coil conductors 12a and 12b, and the connecting conductor 14 from an inductor 2 that is another thin film magnetic inductive component composed of the magnetic

insulative substrate 11, the coil conductors 13a and 13b, and the connecting conductor 14. "Magnetically isolated" here, means that induced voltage is not mutually generated when electric current flows in the inductor 1 or inductor 2 in operation as a power supply. That means the mutual inductance is low enough not to affect operation of the power supply.

[0014]

Fig. 3 is a cross sectional view of a principal part of the first example of a micro power converter with plural outputs. A semiconductor substrate 22 installing a power supply integrated circuit (IC) is disposed over one surface, upper surface here, of the magnetic insulative substrates 11. Inductors and power supply IC, which are two types of major components of a power converter, are integrated and miniaturized in the whole. The power supply IC is designed to have two output systems. Since two inductors are also formed, the power converter provides two outputs. Stud bumps 21 are formed on electrodes of the power supply IC formed on the semiconductor substrate 22. The semiconductor substrate 22 and the connection terminals 15a formed on the magnetic insulative substrate 11 are ultrasonically bonded through the stud bumps 21. Underfil 23 can be provided for sealing as necessary.

[0015]

A capacitor is omitted in Fig. 3. Although discrete capacitors may be provided, a capacitor component of laminated ceramic

capacitor array can be connected to the connection terminal 15b formed on the other side of the magnetic insulative substrate 11 for further miniaturization.

The connection terminals 15a and 15b are electrically connected through a connecting conductor 16. The coil conductors 12a, 12b, 13a, and 13b are covered with a protective film 18 of an insulative resin material, though not shown in the plan view of Fig. 1.

The Figs. 4 through 13 show a method for manufacturing the first example of embodiment of a micro power converter with plural outputs and are cross sectional views illustrating essential steps in sequence of the manufacturing processes. The figures illustrate a manufacturing method for inductors, and the cross sections are similar to the cross section along Y-Y in Fig. 1.

[0016]

A magnetic insulative substrate used was a ferrite substrate 11 of Ni-Zn having a thickness of 525 μm. A thickness of the magnetic insulative substrate is determined depending on necessary inductance, coil current, and properties of the magnetic substrate, and is not limited to the value of this example. However, if the magnetic insulative substrate is extremely thin, magnetic saturation tends to occur; if the substrate is too thick, the power converter itself becomes thick. Accordingly, the thickness needs to be determined matching to purpose of the power converter. Though a magnetic insulative substrate of ferrite was used in the example, other any

appropriate insulative and magnetic substrate can also be used. A ferrite substrate was used here for ease of shaping to a substrate form.

[0017]

First, a ferrite substrate 11 is cut for forming a magnetically isolating layer in the ferrite substrate as shown in Fig. 4. The cutting can be conducted using any method selected from laser beam machining, sand blasting, electric discharge machining, ultrasonic machining, and dicing. Dicing was employed in this example to cut the magnetic insulative substrate into two halves. The magnetic insulative substrate was fixed with a tape 10 in advance to prevent the cut portions of the magnetic insulative substrate from being apart from each other. Thickness of the blade of dicing was 60 μm and the gap 41 of the cut was 70 μm.

Material of the tape 10 can be a thermally peeling tape that decrease adhesivity by heat or an ultraviolet radiation peeling tape that decrease adhesivity by irradiation of ultraviolet radiation. Any tape can be used as far as it holds adhesivity at dicing and is easily peeled off in a later step. An ultraviolet radiation peeling tape was used in this example.

[0018]

The gap of cut was filled with liquid resin and thermally cured to form a magnetically isolating layer 17 of nonmagnetic material, which bonds the two magnetic insulative substrates, as shown in Fig.

5. Filling of the cut gap with resin was performed by repeating several times the steps in which liquid resin was placed at the cut gap by means of screen printing and the liquid resin was cured. The resulted surface was polished so that a step between the surface of the ferrite substrate and the resin surface is eliminated.

Through holes 42 and 43 were then formed as shown in Fig. 6 for connecting coil conductors 12a, 13a, and connection terminals 15a in the first principal surface, and corresponding member of coil conductors 12b, 13b, to the connection terminals 15b in the second principal surface. The coil conductors are connected through the through hole 42, and the connection terminals are connected through the through hole 43. Machining of the through holes 42 and 43 can be conducted by any method among laser beam machining, sand blasting, electric discharge machining, ultrasonic machining, and drilling. A method is to be selected taking machining cost and machining dimensions into consideration. The sand blasting method was employed in this example since the minimum width of the machining dimension was a small value of 130 μm and a large number of places were to be machined.

[0019]

A seed layer of Ti/Cu for plating 44 was deposited by sputtering on the whole surface of the magnetic insulative substrate as shown in Fig. 7 as a pretreatment for forming connecting conductors 14 and 16 in the through holes 42 and 43, coil conductors 12a, 12b, 13a and 13b

on the first and second principal surfaces, and connection terminals 15a and 15b. The seed layers 44 for plating are also formed on the surface of the through holes 42 and 43. The seed layer for plating 44 can alternatively formed by electroless plating. The sputtering method can be replaced by vacuum deposition or CVD (chemical vapor deposition). The method is desired to provide sufficient adhesiveness with the ferrite substrate 1. The conductive material can be any appropriate material exhibiting electrical conductivity. Though titanium was used for the adhesive layer, other materials including Cr, W, Nb, and Ta can also be used. The copper works as a seed layer for electroplating in the next step. The copper can also be replaced by nickel or gold. The copper / titanium was selected in this example considering ease of machining in the later steps.

[0020]

Then, a pattern for forming coil conductors 12a, 12b, 13a, 13b and connection terminals 15a, 15b on the first and second principal surfaces is formed using photoresist 45 as shown in Fig. 8. The pattern was formed with negative type, film type photoresist 45.

The opening portion of the resist pattern is electroplated with copper to form a copper pattern composing coil conductors 12a, 12b, 13a, 13b as shown in Fig. 9. The through holes 42 and 43 are simultaneously plated with copper forming the copper pattern composing connecting conductors 14 and 16. The coil conductors 12a, 13a on the first principal surface and the coil conductors 12b, 13b on

the second principal surface are connected by the connecting conductors, to form a coil pattern having a solenoid shape. At this stage, the seed layer for plating 44 remains on the whole surface of the ferrite substrate 11.

[0021]

After the electroplating, the photoresist 45 and unnecessary conductive layer (a seed layer 44 of copper / titanium) are removed as shown in Fig. 10. Thus, a coil conductor with solenoid shape comprising the coil conductors 12a, 12b, 13a, 13b and the connection terminals 15a, 15b is obtained.

The coil conductors 12a, 12b, 13a, 13b are covered with protective film 18 of an insulator film as shown in Fig. 11. A film type insulator material was used in this example. The protective film is not indispensable. But, the film is preferably formed considering long term reliability. The protective film is not limited to forming with film type material, and liquid insulator material can also be used to form a pattern by screen printing followed by thermal curing.

[0022]

Surfaces of the coil conductors 12a, 12b, 13a, 13b and the connection terminals 15a, 15b may be plated with nickel or gold to form a surface treatment layer, as necessary. In the process shown in Fig. 9 in this example, nickel and gold, not shown in the figure, were electroplated subsequently to electroplating of copper. The surface treatment layer may be formed after the step of Fig. 10 by electroless

plating. Or the electroless plating may be conducted after the step of Fig. 11. The surface treatment layer of metallic protective conductor is helpful for holding stable condition in a later step of connecting the IC.

Then, a semiconductor substrate 22 installing a power supply IC is connected to the connection terminals 15a formed on the ferrite substrate 11 as shown in Fig. 12. In this example, stud bumps 21 are formed on an electrode, not shown in the figure, in the semiconductor substrate, and the stud bumps are fixed to the connection terminals 15a by ultrasonic bonding.

[0023]

The semiconductor substrate 22 is fastened to the inductors 1 and 2 with an underfil 23 as shown in Fig. 13. The semiconductor substrate 22 is fixed to the inductors 1 and 2 using the stud bumps 21 and ultrasonic bonding in this example. A method of the fixing is, however, not limited to this measure. Soldering or a method using a conductive adhesive can also be used. Nevertheless, resistance of connection parts is favorably as small as possible.

The semiconductor substrate 22 was fastened to the inductors 1 and 2 with the underfil material in this example. The fastening, however, can be performed using any appropriate material, for example, a sealant of epoxy resin. The fastening member fastens each of the components (ICs and inductors) and is preferably provided for obtaining long term reliability, though does not affect initial

performance of the power converter.

[0024]

By employing the above-described processes, a power converter packaging parts (a power supply IC and inductors) excepting a capacitor, can be miniaturized. The power converter having two output systems occupies smaller packaging area than two micro power converters having one output system each.

Specifically describing, a micro power converter with one output system has a size of 3.5 mm wide and 3.5 mm long. To obtain two outputs by that type of converter, a packaging area of at least 3.5 mm x 7.2 mm is required. A micro power converter with plural outputs having two output systems allows reducing number of electrodes of a power supply IC, since some electrodes can be shared by the two output systems. Thus, the packaging area is reduced to 3.5 mm wide and 5.8 mm long. A thickness is about 1 mm, which is equal to a thickness of a micro power converter having one output system. By virtue of reduction of packaging area and reduction of assembling steps, which results from change to one micro power converter with plural outputs from two micro power converters, packaging costs can be reduced to a half.

[0025]

Further miniaturization can be achieved by bonding a laminated ceramic capacitor to the connection terminals of the inductor on the reverse side from the face that packages the IC.

[Example 2]

Fig. 14 shows a method for manufacturing a micro power converter with plural outputs of second example of embodiment of the present invention. Fig. 14(a) through Fig. 14(c) are cross sectional views of essential parts in sequence of manufacturing steps. The figures illustrate a process to fabricate ferrite substrate.

The second example of embodiment employs a ceramic material for magnetically isolating layer 17 in place of a resin in the first example of embodiment. As described previously for use of resin, a gap 41 of cut in the ferrite substrate 11 was formed after sintering step of the ferrite substrate and the gap was filled with resin. In the second example of embodiment, however, the ferrite and a ceramic are simultaneously sintered.

[0026]

A green sheet 51 is prepared before sintering the ferrite, as shown in Fig. 14(a).

A gap 52 of cutting and through holes 53, 54 are formed in the green sheet 51 by punching as shown in Fig. 14(b).

The gap 52 is filled with ceramic paste 55 of alumina before sintering by a printing method as shown in Fig. 14(c). The ferrite and the ceramics in this disposition are sintered at the same time at 1,200°C. The sintering temperature, degree of thermal shrinkage due to sintering, and coefficient of thermal expansion of the ferrite and the ceramics are adjusted in this process so that cracks that would

occur after the sintering are avoided and positional accuracy of the through holes is adjusted.

[0027]

Alumina was used for a ceramic material in this example. However, any material that allows adjusting thermal expansion rate and thermal shrinkage rate, and thermal expansion coefficient with respect to those of ferrite can be used including barium titanate, magnesium oxide, zinc oxide, and PZT (lead zirconate titanate).

Steps for forming coils after forming the ferrite substrate are similar to the steps shown in Figs 7 through 13. The method of this Example 2, as compared with Example 1, exhibits superior heat resistance and shows better results in long term reliability tests including pressure cooker tests and THB (temperature humidity bias) tests and in reliability tests including heat cycle tests and heat shock tests since the coefficient of thermal expansion of the materials is adjusted. The effects obtained in Example 1 can be, of course, attained in this Example 2.

[0028]

Number of integrated inductors can be increased corresponding to output systems, from the two inductors that were installed in Example 2. Such an example is shown in Fig. 15 in which four inductors are integrated. Increased number of inductors is to be designed considering output systems required by portable equipment mounting the power converter on the one hand and costs of packaging

and the power converter on the other hand.

The coil pattern can also be varied from the solenoid in this example to a spiral shape or a toroidal shape. A magnetically isolating layer can be formed for those shapes and a micro power converter with plural outputs can be produced employing these shapes similarly to the case of the solenoid shape.

[0029]

[Effect of the invention]

As described thus far, a plurality of inductors is integrated in a magnetic insulative substrate with a magnetic isolation layer between the inductors. Such a structure forms a micro power converter with plural outputs. A plurality of micro power converters that was required in the prior art corresponding to output systems can be aggregated to one device in an invented micro power converter. Such a converter of the invention reduces a packaging area and packaging costs.

[Brief description of drawings]

Fig. 1 is a plan view of an essential part of the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 2(a) is a cross sectional view along the line X-X in Fig. 1 of an essential part of an inductor shown in Fig. 1.

Fig. 2(b) is a cross sectional view along the line Y-Y in Fig. 1 of

an essential part of inductors shown in Fig. 1.

Fig. 3 is a cross sectional view of an essential part of the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 4 is a partial sectional view illustrating a step of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 5 is a partial sectional view illustrating a step, following the step of Fig. 4, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 6 is a partial sectional view illustrating a step, following the step of Fig. 5, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 7 is a partial sectional view illustrating a step, following the step of Fig. 6, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 8 is a partial sectional view illustrating a step, following the step of Fig. 7, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 9 is a partial sectional view illustrating a step, following the

step of Fig. 8, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 10 is a partial sectional view illustrating a step, following the step of Fig. 9, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 11 is a partial sectional view illustrating a step, following the step of Fig. 10, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 12 is a partial sectional view illustrating a step, following the step of Fig. 11, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 13 is a partial sectional view illustrating a step, following the step of Fig. 12, of manufacturing the first example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 14(a) is a partial sectional view illustrating a step for forming a ferrite substrate in the second example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 14(b) is a partial sectional view illustrating a step, following

the step of Fig. 14(a), for forming the ferrite substrate in the second example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 14(c) is a partial sectional view illustrating a step, following the step of Fig. 14(b), for forming the ferrite substrate in the second example of embodiment of a micro power converter with plural outputs according to the present invention.

Fig. 15 is a partial sectional view illustrating four inductors integrated on a magnetic insulative substrate.

Fig. 16 shows a DC-DC converter circuit.

[Description of symbols]

1, 2	inductor
10	tape
11	magnetic insulative substrate / a ferrite substrate
12a, 13a	coil conductor (on first principal surface)
12b, 13b	coil conductor (on second principal surface)
14, 16	connecting conductor
15a	connection terminal (on first principal surface)
15b	connection terminal (on second principal surface)
17	magnetically isolating layer
18	protective film (insulative film)
21	stud bump
22	semiconductor substrate

23	underfil
42, 43, 53, 54	through hole
44	seed layer for plating
45	photoresist
51	ferrite green sheet
55	ceramic paste

[Document Type] Abstract

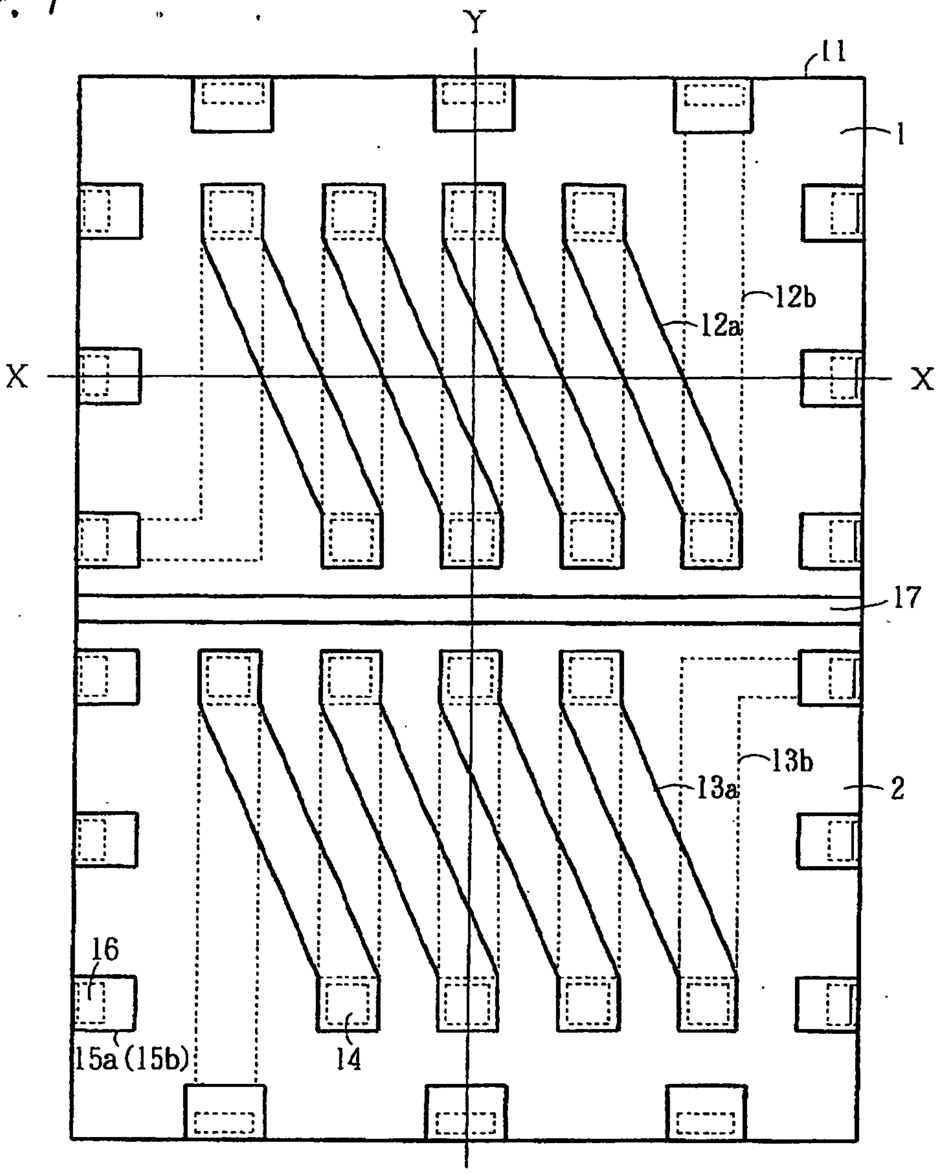
[Abstract]

[Problem] An object of the present invention is to provide a micro power converter with plural outputs that outputs plural voltage outputs, is small and thin, occupies small packing area, and has plural output systems.

[Means to solve the problem] A micro power converter with plural outputs according to the present invention comprises two inductors 1, 2 each having a solenoid coil. The coils are composed of coil conductors 12a, 13a formed on a first principal surface of a magnetic insulative substrate 11, coil conductors 12b, 13b having a planar form of a straight line formed on second principal surface of the substrate, and connecting conductors 14 in through holes, the connecting conductors electrically connecting the coil conductors on the first principal surface to the coil conductors on the second principal surface. The two inductors 1, 2 are magnetically isolated from each other by a magnetically isolating layer 17. A micro power converter having plural outputs is obtained by provision of the plural inductors.

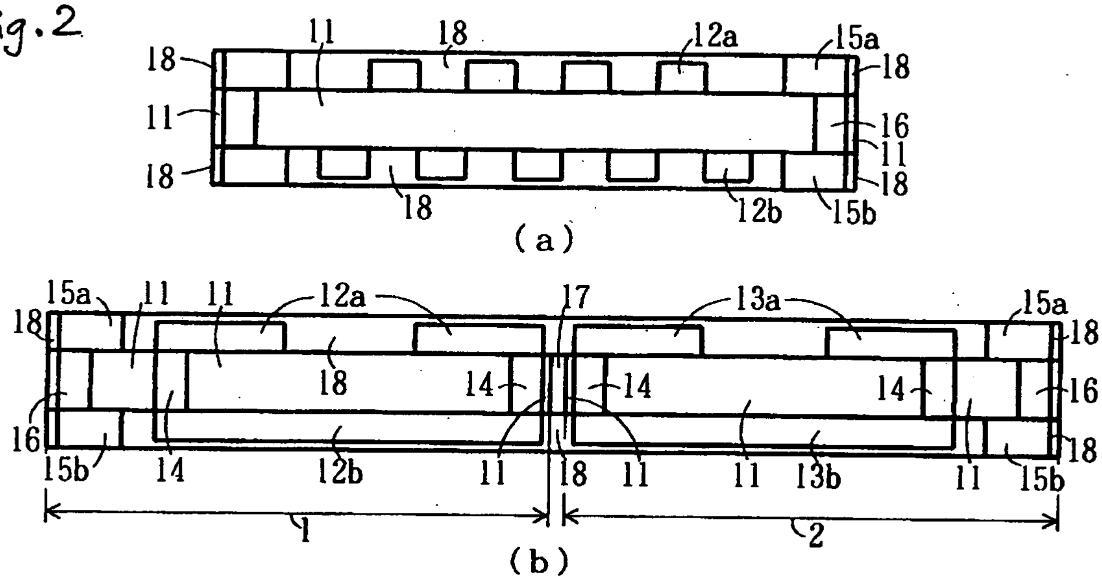
[Selected drawing] Figure 1

Fig: 1

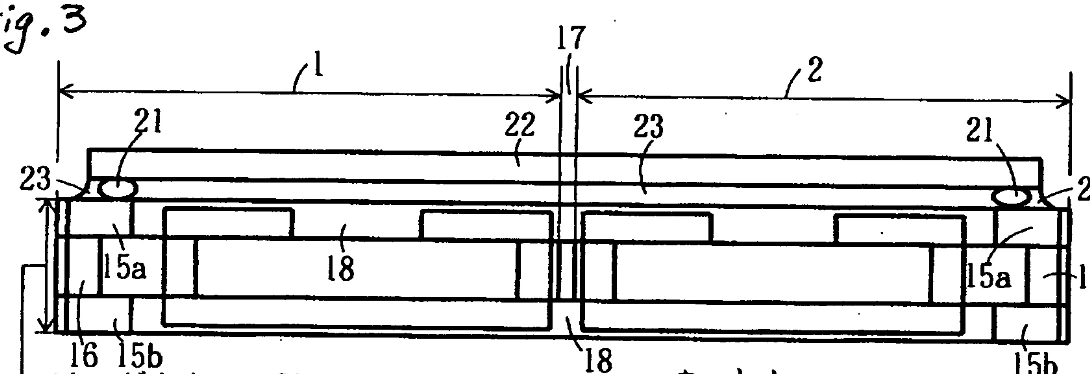


1 inductor
2 inductor
11 magnetic insulative substrate (a ferrite substrate)
12a coil conductor on first principal surface
12b coil conductor on second principal surface
13a coil conductor on first principal surface
13b coil conductor on second principal surface
14 connecting conductor
15a connection terminal on first principal surface
15b connection terminal on second principal surface
16 connecting conductor
17 magnetically isolating layer

~~【図2】~~
Fig. 2

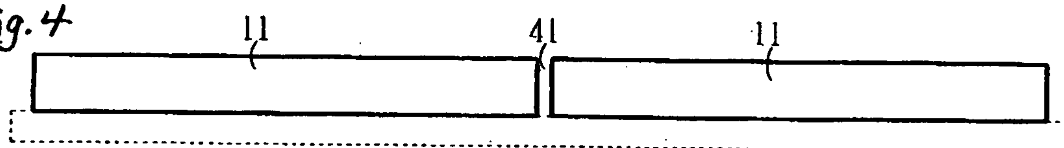


~~【図3】~~
Fig. 3



~~インダクタ~~ inductor
21 · · · ~~スタッドバンプ~~ → stud bump
22 · · · ~~半導体基板~~ → semiconductor substrate
23 · · · ~~アンダーフィル~~ → underfil

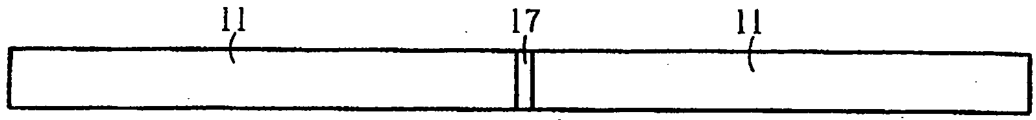
~~【図4】~~
Fig. 4



10 · · · ~~テープ~~ tape
41 · · · ~~切り代~~ cut gap

~~【図5】~~

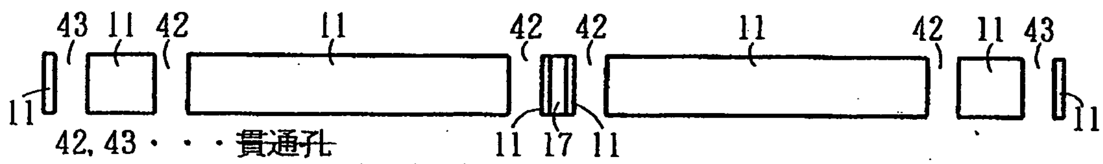
Fig. 5



17・・・~~磁気分離層~~ magnetically isolating layer

~~【図6】~~

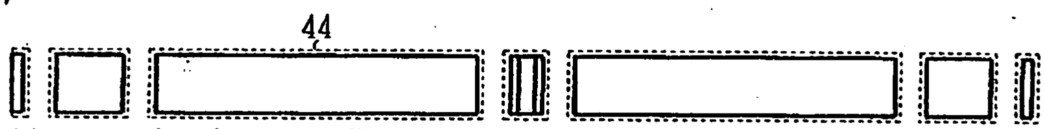
Fig. 6



42, 43・・・~~貫通孔~~ through hole

~~【図7】~~

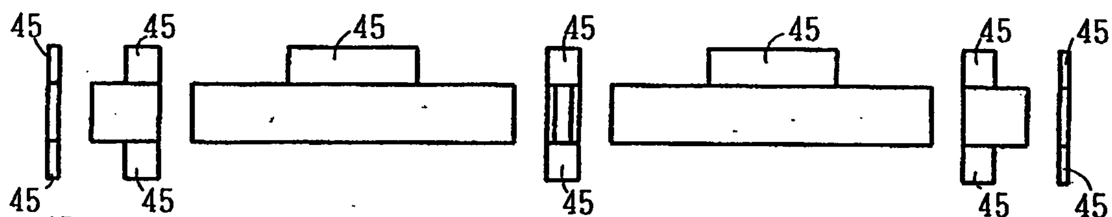
Fig. 7



44・・・~~めっきシード層~~ seed layer for plating

~~【図8】~~

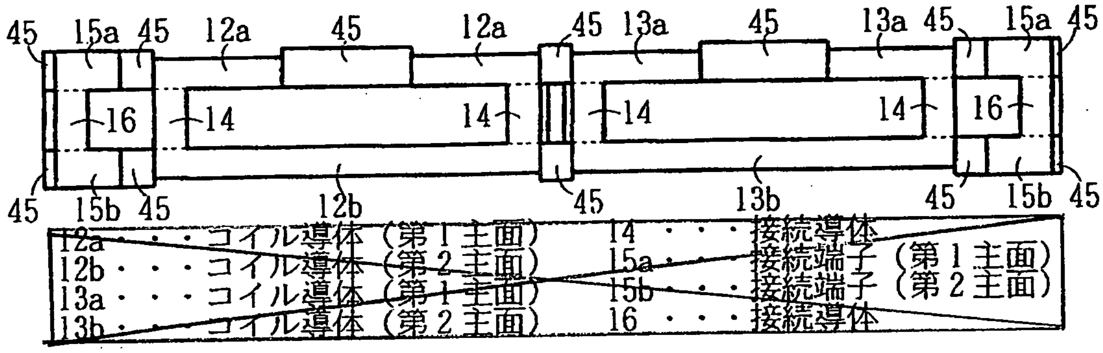
Fig. 8



45・・・~~フォトレジスト~~ photoresist

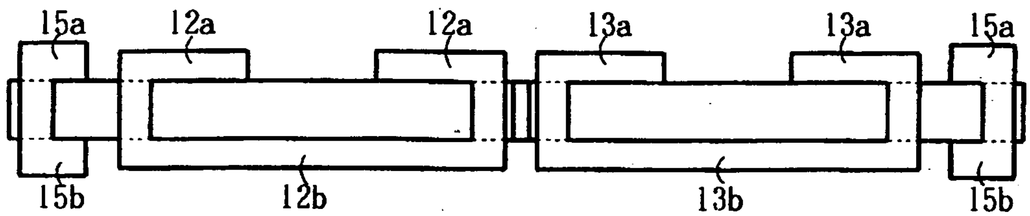
~~【図9】~~

Fig. 9

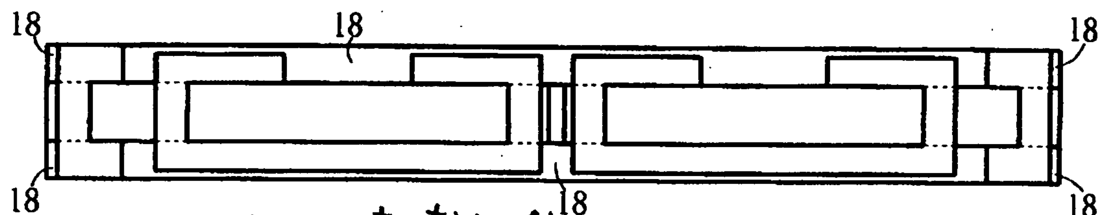


12a	coil conductor on first principal surface
12b	coil conductor on second principal surface
13a	coil conductor on first principal surface
13b	coil conductor on second principal surface
14	connecting conductor
15a	connection terminal on first principal surface
15b	connection terminal on second principal surface
16	connecting conductor

~~【図10】~~ Fig.10

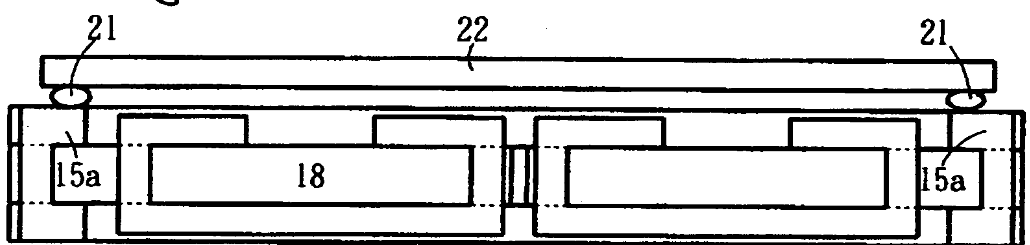


~~【図11】~~ Fig.11



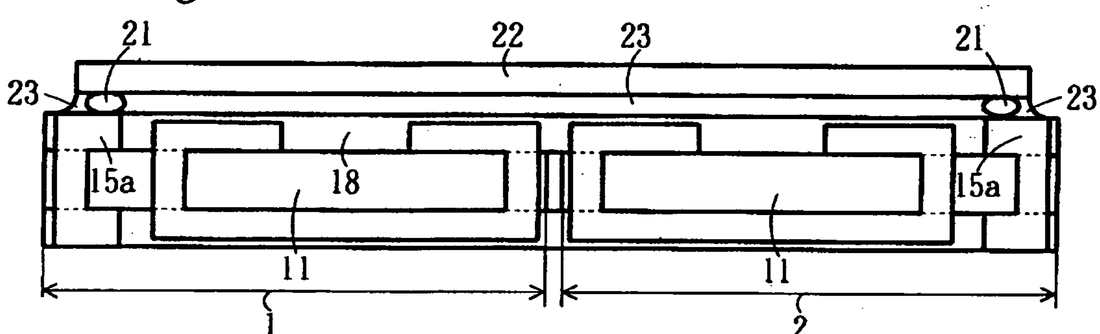
18・・・~~保護膜~~ protective film

~~【図12】~~ Fig.12



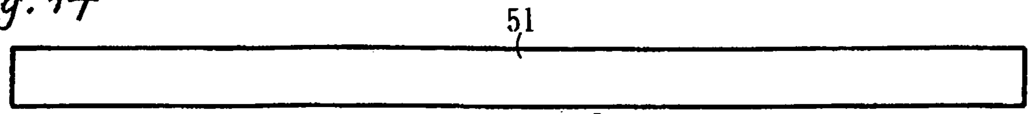
21・・・~~スタッドバンプ~~ stud bump　22・・・~~半導体基板~~ semiconductor substrate

~~【図13】~~ Fig.13

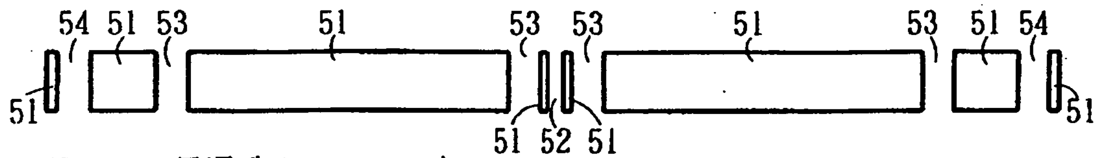


23・・・~~アンダーフィル~~ underfil

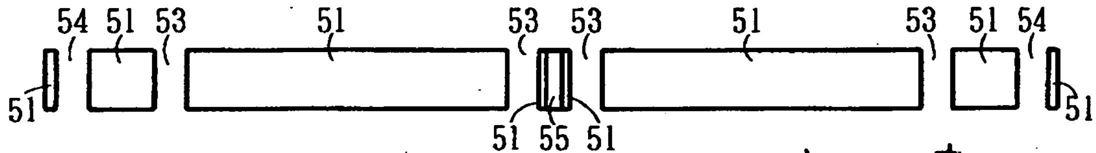
~~【図14】~~
Fig. 14



51・・・~~フェライトグリーンシート~~ → ferrite green sheet
(a)

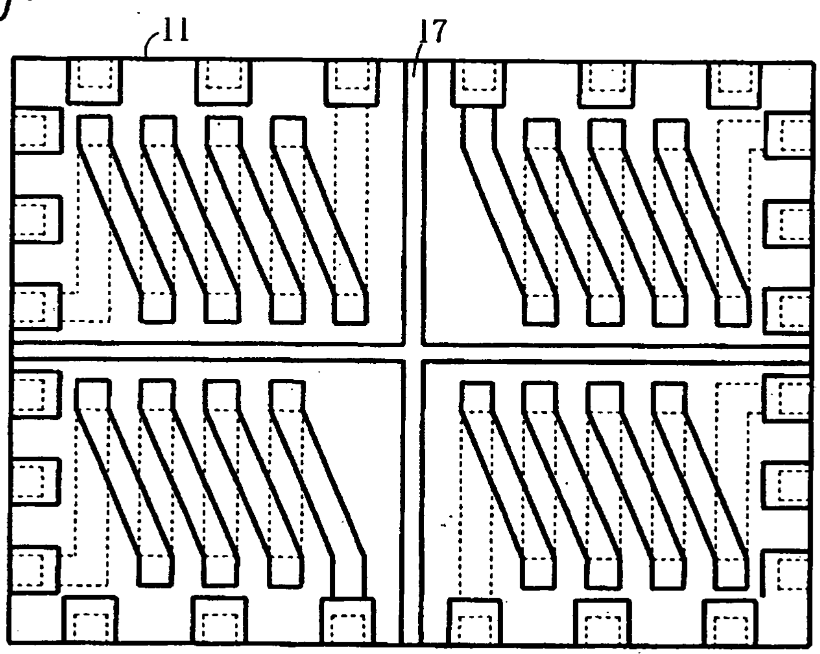


53・・・~~貫通孔~~ } through hole
54・・・~~貫通孔~~
(b)



55・・・~~セラミックスペースト~~ → ceramic paste
(c)

~~【図15】~~
Fig. 15



~~【図16】~~

Fig. 16